

R. N., in the *British Medical Journal*, Jan. 30, 1915, dealing with *Schistosoma*, and having as an appendix a note by Mr. G. C. Robson describing the mollusk which serves as host for its cercariæ. This mollusk is called *Katayama nosophora* n. g. et sp. It is undoubtedly identical with the form sent me by Professor Goto, and described above. As I have already had the figures for my article engraved, I allow it to stand as written, merely substituting Mr. Robson's specific name for my own. It may be useful to point out that the mollusk in question belongs to the long-known genus *Blanfordia*, and that the new genus *Katayama* is therefore superfluous. Mr. Robson was naturally misled by the wrong position assigned *Blanfordia* by the older authorities.

SOME EXCEPTIONAL CASES OF BREEDING AMONG THE UNIONIDÆ.¹

BY ARTHUR D. HOWARD.

In collecting material for the study of a somewhat peculiar case of breeding among the Unionidæ, I have incidentally come upon some other instances, which I believe have not been reported. In 1912 I undertook to work out for the United States Bureau of Fisheries, methods of propagation of the Washboard mussel, *Quadrula heros* Say, with other species of *Quadrula*. This species was somewhat uncommon in the vicinity of the laboratory where I was stationed, so that there was a question as to a supply of material. One day I noticed a boatload of shells containing an unusual number of *Q. heros* with many young shells. Enquiring of the owner the source of these, I learned they had come from Moline, Ill., some 25 miles above. I subsequently visited the place, finding it accessible and the species sufficiently abundant to furnish considerable data on breeding as well as material for experiments in propagation.

While collecting the Washboard mussel at this point I obtained evidence of peculiarities in the breeding of three other Unionidæ which, although they may not be of immediate im-

¹Contribution from United States Biological Station, Fairport, Iowa. Published by permission of Commissioner of Fisheries.

portance to the commercial shell buyer, are of undoubted interest to the conchologist. These forms are *Margaritana monodonta* Say, *Hemilastena ambigua* Say, and *Anodonta imbecillis* Say.

Quadrula heros proved to be for this locality a fall breeder, thus an exception to the summer breeding habit of other known *Quadrulas*. Although the time of breeding is different, the evidence obtained pointed to no change as to tachytictic or short breeding habit characteristic of the *Quadrula* group. October seemed to be the principal breeding season, as an abundance of gravid mussels was then obtainable. In November, among many specimens examined, no gravid individuals could be found. I have been interested to learn of cases of breeding during later months. These come from localities further south,¹ and apparently are explainable on the basis of climate. There is, however, the possibility of two breeding times in one season, as has been claimed for some other short-period breeders, for example, *Margaritana margaritifera*. I did obtain one breeding in May from many examined, and a similar case is reported by Lefevre and Curtis, who questioned the correctness of placing this form among winter breeders. These cases seem, however, to be very rare and quite exceptional. There is a difference here, worthy of note I believe, in that the time of retention of glochidia in *Q. heros* is relatively short as compared with other winter breeders. I have given other observations upon this mussel and a discussion of the literature in another paper,² so need not cite them here.

With the collections of *Q. heros*, *Margaritana monodonta* seemed fairly abundant, so that I saw an opportunity to investigate the breeding of this species. Certain indications pointed to an early spring breeding season, and in one expedition in search of it on March 10th, by reason of the collapse of the ice, I came nearer to its place of abode than I cared to be.

¹ Mr. U. T. Utterbach reports gravid *heros* for January and February, and I desire here to acknowledge his kindness in submitting to me material and notes. For other observations see Howard, A. D., 1914, "Experiments in Propagation of Fresh-water Mussels of the *Quadrula* Group." Appendix to the report of the U. S. Commissioner on Fisheries for 1913, pp. 1-52, 6 pls.

² Howard, A. D., 1914, *op. cit.*, pp. 28, 29.

On May 2nd I succeeded in securing a gravid specimen with eggs and glochidia. All four gills were gravid, the inner containing many more than the outer. Upon removing the mussel from the water I at once placed a portion of the inner and outer gills in preserving fluid. Even with this precaution, the initiation of abortion was evident. The remainder of the mussel, shell and soft parts, I wrapped in cloth, not having a container large enough to fix at once. Upon arrival at the home station I found that complete abortion of the contents of the marsupia had taken place.

Glochidia were present, somewhat immature, but Dnapping, with a number of eggs presumably unfertilized. The glochidia are sub-circular in form, *i. e.*, circular except for the rather short straight hinge line. Harms (1907-1909) figuring the glochidia of *M. margaritifera* presents them somewhat pointed and toothed. I can make out neither of these characters in *M. monodonta*. The dimensions are: Height 0.055-0.065 mm., length 0.055-0.0065 mm., thus being a little larger than those reported for *M. margaritifera* and among the smallest of glochidia. As the ovaries are well distended with eggs near maturity I think there is no doubt that at least two broods are produced in a season, as reported (Conner, Harms and Ortmann)¹ for *M. margaritifera*.

I observed segmentation of ovarian eggs in this species in a specimen which had been cut open and exposed to river water. No data to my knowledge has been obtained relative to the hosts for this species.

Hemilastena ambigua :—Nets placed near the mussel bed, for the purpose of determining the host fishes of *Q. heros* yielded some material that presented quite another problem. With the fishes caught were a number of mud puppies, *Necturus maculosus*, Rafinesque. From a total of fifteen caught twelve or 80 per cent were infected with glochidia of mussels. Upon attempting to identify these a few were found to be *Q. heros* not imbedded, nor becoming so, after an attachment for a known period of twenty-four hours and more. Evidently they were merely ac-

¹ See Ortmann, 1914. Annals Carnegie Museum, vol. 8, no. 2, 1912, p. 232.

cidental infections upon an inappropriate host. The great majority of infections were by a glochidium unknown to me. They were deeply imbedded in the external gills of the *Necturus* and by keeping the animals alive all winter I succeeded in carrying the young mussels through to the juvenile stage, these being shed the last week in May, soon after which I obtained the young mussels. The parasitic period is a long one from the date the infected salamanders were captured, October 17th to the last of May, being over 7 months. By this test the appropriateness of the host was satisfactorily demonstrated.

These glochidia were different from any in our station collection of which we supposedly had a complete faunal set with one or two exceptions which I knew did not answer the case in question. I looked up all the known *Najades* which might have a range to the Mississippi River in Eastern Iowa and found that one species was given which we did not have. This was *Hemilastena ambigua*, Say or *Unio hildrethianus*, Lea. An inquiry at the Academy of Sciences, Davenport, Ia., disclosed the fact that there was one record of collection for Davenport.¹

Lea² figures the glochidium of this species but it is so small and so like that of other species that without dimensions a certain identification could not be made from it. As the likelihood of finding material in some collection seemed slight I decided to look for gravid mussels and make a direct comparison. From the literature and such information as could be gathered from experienced collectors, this rare species has the peculiar habit of living under flat stones. This seemed to present a difficulty in collection, for the water was deep at the point where the *Necturus* had been taken. I had dredged here considerably but no example of this species were in the hauls. Their habitat would seem to account for this failure to secure them as an ordinary boat dredge would be likely to miss them protected as they are by the stone above. The best chance for success seemed to be to locate them in some small stream. In Mr. F.

¹ I am indebted to the Davenport Academy of Sciences for their assistance in this matter and especially to Mr. Paarmann and Miss S. F. Sheldon who kindly looked up the specimen and records.

² Lea, Isaac, Observations on the Genus *Unio*, vol. vi, p. 49, pl. 5, fig. 31.

C. Baker's "Mollusca of the Chicago Area," he cites the collection of this species under such conditions. By correspondence with Mr. Baker I learned the names of the collectors¹ who kindly gave me directions for locating the species which they had taken many years previous. The first five specimens I found were not gravid; so that I feared it was too early or too late. Upon examination with a microscope all proved to be males. Returning to the stream again I found 9 gravid mussels out of a total of 17. The first of these contained glochidia which corresponded exactly with the glochidia found on *Necturus* in the Mississippi, thus giving me the link I desired to make out the life history.

The glochidia are clear white in color, of the triangular type with well-developed hooks, contrary to the description given by Lea, who however suggested the possibility of hooks in more mature specimens. The dimensions are as follows: Height 0.265 to 0.274 mm., length 0.247 to 0.555 mm.

All of the adult individuals were found under flat stones of the flag-stone type characteristic of the limestone in the region. Beneath a single rock I found four. While exploring the under surface of these I felt and seized a wriggling animal which proved to be a mud-puppy, demonstrating the manner in which *Necturus* becomes inoculated. Glochidia shed by the mussels in such a location would not have a rapid dispersal by currents so that the *Necturus* commonly seeking such a shelter would run the chance of a heavy infection. The finding of a mussel parasitic upon a salamander as the appropriate host instead of a fish is the first instance I have known recorded among American mussels. Faussek² in St. Petersburg experimented with Amphibia artificially infected with glochidia of *Anodonta*. He reported successful infection upon *Axolotl* and *Proteus*.

Anodonta imbecillis:—While endeavoring to identify the gloc-

¹ I wish here to acknowledge the kindly assistance and courtesies extended to me by the following gentlemen: Mr. F. C. Baker, Chicago Academy of Sciences; Messrs. J. B. Brown, J. H. Ferriss, J. H. Handwerk and Dr. Alfred Houston, of Joliet, Ill., and Mr. Bryant Walker, of Detroit.

² Faussek, 1901. Ueber den parasitismus der *Anodonta*-Larven. Verhandlungen des V. Internationalen Zoologischen-Congresses (Berlin), pp. 761-766.

hidia which have been described above as parasitic upon *Necturus* I observed a similarity to the glochidia of *Anodonta imbecillis*, Say. A minute comparison showed differences however and I made an effort to determine if the differences might come within the range of normal variation. To do this I secured as many gravid examples of *A. imbecillis* as I could from the place where the *Necturus* were captured. In a measurement of glochidia from 16 individuals I found that only the very lowest point of variation in *A. imbecillis* corresponded with the larger of the unknown. It was quite obvious they could not be the same species. While making this examination which yielded negative results to my original search I noted a peculiarity which proved quite a diversion. In measuring the glochidia I came upon individuals which had advanced far beyond the larval stage, having in fact reached a point of development equal to that to be seen in most Unionidae after metamorphosis parasitically upon fishes.

The young mussels, mostly of the same stage, lie crowded in the marsupial gill of the parent without apparently any matrix or conglutinate structure whatever. In this respect we have a condition quite different from that reported by Lefevre and Curtis¹ for the non-parasitic development of *Strophitus edentulus* (Say), in which there is a matrix sub-divided into the so-called cords.

Among the six lots of marsupial juveniles that I collected the degree of development varied slightly as to amount of shell growth, otherwise there seemed to be little difference. This growth consists of a narrow rim only, around the edge of the glochidial shell. The hooks of the glochidium are still much in evidence, but are much weaker than in parasitic forms. A noticeable feature is the large proportion of gaping shells as compared with a similar lot of glochidia. It would seem that with the loss of the powerful single adductor muscle the action of closing is less vigorous. Between the gaping valves can be seen the ciliated foot, two adductor muscles, the mantle, on each side, the gill papillæ, etc.

¹ Lefevre and Curtis. Bull. of the Bureau of Fisheries, vol. xxx, 1910 (issued 1912).

Observations upon the seasons of breeding reveal further peculiarities. Among lots examined in May and November were found individuals carrying in the marsupial gills embryos representing all stages of development except unsegmented eggs. The following counts from two collections will illustrate this:

Locality.	Date.	Stage of Gravidity.					Total.
		Eggs.	Early Embryo.	Late Embryo.	Glochidia.	Juveniles.	
Moline, Ill.	November 7, 1913.	7	3	7	5	22
Fairport, Ia.	May 1, 1914.	2	1	5	6	14

This lack of uniformity in the late fall and early spring counts, it will be seen, does not correspond with the usual conditions to be found in the bradytic or winter breeders.

In the absence of parasitism this species must lose the usual method of distribution through the migrations of the host fish. What seems to be a compensatory provision for this loss is to be seen in the peculiar light and flattened type of shell of the juvenile, which subjects it to ready transference by water currents. I have described in another paper¹ with fuller discussion the finding of this species in artificial ponds and reservoirs, whither, in the loss of the parasitic habit, they had been carried doubtless by the water supply.

To summarize:

1. *Quadrula heros* as compared with other *Quadrulas* and members of the *Crenodonta* group shows a postponement of breeding time from summer to autumn and winter.

2. *Margaritana monodonta* possesses exceptionally small glochidia, and there is evidence of at least two broods in a season.

¹ Howard, A. D., 1914. A Second Case of Metamorphosis without Parasitism in the Unionidæ. Science N. S., vol. xi, no. 1027, pp. 353-355, Sept. 4, 1914.

3. *Hemilastena ambigua* is parasitic in nature upon the amphibian, *Necturus maculosus*, which in the cases observed became inoculated in the fall, the young mussels being released the last of May.

4. *Anodonta imbecillis* develops without parasitism and gives evidence of broad limits in the range of the breeding season.

THE DALL BANQUET.

A banquet to Dr. William Healey Dall, commemorating the completion of fifty years of service to science, was given by his friends at the Cosmos Club, Washington, on the evening of April 21.

Dr. Charles D. Walcott, Secretary of the Smithsonian Institution, was to preside, but in his absence, due to the death of his father-in-law, Dr. Robert S. Woodward, President of the Carnegie Institution of Washington, took the part of toastmaster with wit and grace.

The Toasts :

Dall the Alaska Pioneer—Dr. Alfred H. Brooks.

Dall the Anthropologist—Prof. Wm. H. Holmes.

Dall the Coast Pilot—Mr. Isaac Winston.

Dall the Malacologist—Dr. Henry A Pilsbry.

Dall the Paleontologist—Dr. T. Wayland Vaughan.

Dall the Zoologist—Dr. C. Hart Merriam.

Dall the Nomenclatorist—Dr. Ch. Wardell Stiles.

Dall the Poet—Justice Wendell P. Stafford.

Dall the Man—General A. W. Greely.

Dr. Dall's response.

Letters from absent friends of Dr. Dall were read by Dr. Whitman Cross, Dr. Frederick A. Lucas, Mr. W. E. Safford and Mr. Paul Brockett.

The speakers were in friendly rivalry to claim Dall for their own special branches of science. Among paleontologists he is acknowledged the great leader in all relating to cenozoic faunas. His "Tertiary Fauna of Florida" is a classic of American paleontology. For years he has been the foremost authority on zoological nomenclature in America. Malacologists almost forget that Dall's work on recent mollusks is only one phase of his many-sided scientific activity, since that alone seems so large an